Firearms-related injury and sex: a comparative National Trauma Database (NTDB) Study

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ABSTRACT

Background Existing study findings on firearms-related injury patterns are largely skewed towards males, who comprise the majority of this injury population. Given the paucity of existing data for females with these injuries, we aimed to elucidate the demographics, injury patterns, and outcomes of firearms-related injury in females compared with males in the USA.

Materials and methods A 7-year (2013–2019) retrospective review of the National Trauma Database was conducted to identify all adult patients who suffered firearms-related injuries. Patients who were males were matched (1:1, caliper 0.2) to patients who were females by demographics, comorbidities, injury patterns and severity, and payment method, to compare differences in mortality and several other post-injury outcomes.

Results There were 196,696 patients admitted after firearms-related injury during the study period. Of these patients, 23,379 (11.9%) were females, 23,378 of whom were successfully matched to a male counterpart. After matching, females had a lower rate of in-hospital mortality (18.6% vs. 20.0%, p<0.001), deep vein thrombosis (1.2% vs. 1.5%, p=0.014), and had a lower incidence of drug or alcohol withdrawal syndrome (0.2% vs. 0.5%, p<0.001) compared with males.

Conclusion Female victims of firearms-related injuries experience lower rates of mortality and complications compared with males. Further studies are needed to elucidate the cause of these differences.

Level of evidence Level III.

INTRODUCTION

Penetrating trauma is the third leading cause of injury in the USA, with more than 218,000 homicides from 2004 to 2018, and accounting for 8% to 10% of all reported injuries.1–3 The USA has the highest incidence of firearm fatalities of all developed countries, and firearms-related injuries and mortalities have been rising annually.2,4,5

In the USA, females are 21 times more likely to die from firearm injuries than females in any other developed nations,6 with previous studies indicating worse outcomes in female patients compared with men.7–9 Conversely, small single-institution studies suggest that females are three times less likely to sustain penetrating injuries with less injury severity and half mortality rates compared with male victims.10–13

Studies conducted using national databases have not compared the outcomes for firearm injuries among females to males. As the incidence of firearm violence rises, providers should understand the trauma care needed in female versus male victims of firearms-related injuries.2,4,5

The objectives of this study were to describe the injury characteristics between the two sexes and determine the differences in outcomes in female victims of firearms-related injuries compared with males.

MATERIALS AND METHODS

The National Trauma Database (NTDB) was used to identify all adult patients (18 years or older) who suffered a firearms-related injury between 2013 and 2019. Patients were excluded if they had an Abbreviated Injury Scale (AIS) of 6 in any body region, since these injuries are generally not considered survivable, if they were discharged alive in less than 1 day from admission, or if sex was not registered in NTDB. The retrieved data included patient demographics, clinical characteristics, injury severity, comorbidity, and clinical outcomes. This investigation complies with both the Strengthening the Reporting of Observational Studies in Epidemiology guidelines and the Declaration of Helsinki.12,13

Statistical analysis

Patients were divided into two groups based on their sex: female or male. All variables were presented before and after propensity score matching. In the unmatched data, continuous, normally distributed variables were summarized using a mean and SD, with the statistical significance of differences being determined using the Student’s t-test. Continuous, non-normally distributed variables were
summarized using a median and IQR, with the statistical signifi- 
cance of differences being calculated using the Mann-Whitney U 
test. Categorical variables were presented as counts and percent-
ages with differences in the distributions being determined using 
the X² test. The primary outcome of interest was in-hospital 
mortality. Secondary outcomes consisted of hospital length of 
stay and in-hospital complications.

Confounding was managed using propensity score matching. Male 
patients were matched to female patients at a 1:1 ratio with a caliper 
of 0.2. Matching was based on age, race, AIS in each body region,
comorbidities (history of myocardial infarction, history of angina,
congestive heart failure, hypertension, peripheral vascular disease,
cerebrovascular disease, diabetes mellitus, chronic renal failure,
dementia, chronic obstructive pulmonary disease, smoking status,
 liver cirrhosis, coagulopathy, receiving chemotherapy for cancer,
metastatic cancer, drug use disorder, alcohol use disorder, and major 
psychiatric illness), and payment method. After matching, the sta-
tistical significance of differences between the cohorts was determined
using the paired Student’s t-test. Categorical variables were presented as counts and percent-
cance of differences being calculated using the Mann-
summarized using a median and IQR, with the statistical signifi-
cance of differences between the cohorts was determined using 
the paired Student’s t-test (for normally distributed continuous
variables), Wilcoxon signed-rank test (for non-normally distributed continuous variables), or McNemar’s test with Bonferroni correc-
tion (for categorical variables). Two additional subgroup analyses
were also performed. The first analysis only included patients with 
an Injury Severity Score (ISS) ≥15 to assess differences in the most
severely injured patients. The second analysis only included patients 
who were ≥50 years old to reduce the effect of differing levels of

estrogen.

A two-tailed p value of less than 0.05 was considered statisti-
cally significant in all analyses. The statistical programming 
language R (R Foundation for Statistical Computing, Vienna,
Austria) was used to perform all calculations and tabulations,
using the tidyverse, readxl, writexl, and MatchIt packages.

RESULTS
During the study period, 196,696 patients who suffered a 
firearms-related injury met the inclusion and exclusion criteria.
This group consisted of 173,317 (88.1%) males and 23,379
(11.9%) females. Prior to propensity score matching, the female 
cohort were older (females vs. males: 32 years vs 29 years, p<0.001), more likely white (45.5% vs 33.3%, p<0.001), more likely to have private insurance (26.0% vs 20.3%, p<0.001), and less likely to be uninsured (23.6% vs 33.4%, p<0.001) (table 1).

In general, comorbidities were more prevalent or equally prev-


alent in female patients compared with their male counterparts (table 2).

Before propensity score matching, female patients with 
firearms-related injury were more likely to require intensive care unit (ICU) care (43.5% vs. 42.3%, p<0.001). They also 
demonstrated similar rates of in-hospital mortality, unplanned 
admissions to the ICU and pulmonary embolism compared with 
the unmatched male cohort. However, the rates of surgical site 
infections (0.7% vs. 0.9%, p<0.001), deep vein thrombosis (DVT) 
(1.2% vs. 1.6%, p<0.001), and drug or alcohol withdrawal 
syndrome (0.2% vs. 0.4%, p<0.001) were lower among the 
female cohort (table 3).

After propensity score matching, statistically significant, but 
clinically non-significant, differences remained in age (32 years vs.
31 years, p<0.001), the proportion of patients who identified 
as black (42.3% vs. 43.0%, p=0.009), smoking status (24.5% vs.
23.5%, p<0.001), and prevalence of chronic obstructive pulmo-
nary disease (3.3% vs. 3.0%, p=0.016), whereas all other variables 
were fully balanced (tables 1 and 2 and online supplemental table 1).
Females exhibited an overall lower rate of in-hospital mortality 
(18.6% vs. 20.0%, p<0.001), had a lower incidence of drug or 
alcohol withdrawal syndrome (0.2% vs. 0.5%, p<0.001), DVTs
(1.2% vs. 1.5%, p=0.014), and required mechanical ventilation 
less frequently than males (30.5% vs. 32.4%, p<0.001) (table 3).

The results remained unchanged in the subgroup analysis 
consisting of patients with severe firearms-related injury (ISS
≥15). A lower in-hospital mortality rate (44.4% vs. 46.7%, 
p<0.001), need for mechanical ventilation (59.9% vs. 62.8%, 
p<0.001), and a lower incidence of drug or alcohol withdrawal 
syndrome (0.2% vs. 0.6%, p<0.001) were noticed among the 
female cohort (online supplemental tables 2 and 3).

Table 1 Patient demographics and clinical features among men and women with firearms-related wounds

<table>
<thead>
<tr>
<th></th>
<th>Before matching</th>
<th>After matching</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male (N=173 317)</td>
<td>Female (N=23 379)</td>
</tr>
<tr>
<td>Age, median (IQR)</td>
<td>29 (23–39)</td>
<td>32 (24–45)</td>
</tr>
<tr>
<td>Race, n (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>57 789 (33.3)</td>
<td>10631 (45.5)</td>
</tr>
<tr>
<td>Black</td>
<td>91 396 (52.7)</td>
<td>8886 (42.3)</td>
</tr>
<tr>
<td>Asian</td>
<td>1328 (0.8)</td>
<td>225 (1.0)</td>
</tr>
<tr>
<td>American Indian</td>
<td>1163 (0.7)</td>
<td>223 (1.0)</td>
</tr>
<tr>
<td>Pacific Islander</td>
<td>434 (0.3)</td>
<td>57 (0.2)</td>
</tr>
<tr>
<td>Other</td>
<td>16562 (9.6)</td>
<td>1769 (7.6)</td>
</tr>
<tr>
<td>Missing</td>
<td>2863 (1.7)</td>
<td>331 (1.4)</td>
</tr>
<tr>
<td>ISS, median (IQR)</td>
<td>10 (5.0–19)</td>
<td>10 (5.0–19)</td>
</tr>
<tr>
<td>Missing, n (%)</td>
<td>4041 (2.3)</td>
<td>384 (1.6)</td>
</tr>
<tr>
<td>Payment method, n (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private insurance</td>
<td>35 219 (20.3)</td>
<td>6074 (26.0)</td>
</tr>
<tr>
<td>Government insurance</td>
<td>64 331 (37.1)</td>
<td>9978 (42.7)</td>
</tr>
<tr>
<td>Uninsured</td>
<td>57 915 (33.4)</td>
<td>5506 (23.6)</td>
</tr>
<tr>
<td>Other</td>
<td>8447 (4.9)</td>
<td>893 (3.8)</td>
</tr>
<tr>
<td>Missing</td>
<td>7405 (4.3)</td>
<td>928 (4.0)</td>
</tr>
</tbody>
</table>

Age is measured in years. A patient may have had more than one race.
ISS, Injury Severity Score.
Similar results were also observed among patients who were ≥50 years old. Compared with male patients, female patients exhibited a lower risk of in-hospital mortality (27.0% vs. 30.2%, p<0.001), a lower need for mechanical ventilation (38.0% vs. 41.5%, p<0.001), and a lower rate of drug or alcohol withdrawal syndrome (0.5% vs. 1.0%, p=0.009) (online supplemental tables 4 and 5).

**DISCUSSION**

In this analysis, we aimed to identify the differences in mortality and outcomes after firearms-related injury in the USA between female and male patients admitted to hospitals. We found that females have a statistically significant survival advantage after firearms-related injury compared with males, despite exhibiting a similar overall injury burden after matching. In addition, a lower need for mechanical ventilation and complication rate were detected in the female cohort of patients who had suffered a firearms-related injury.

Although it was not feasible to explain the mechanism for the positive findings associated with the female sex in this retrospective register study, there are several plausible explanations to these findings. The difference in mortality rate between female and male victims of firearms-related injuries may be due to the survival advantage that females have based on their relative hypercoagulable profile compared with males. Additionally, there may be some advantages in hormonal differences between the two sexes. Estrogen is thought to be protective and immune enhancing, unlike testosterone which has been shown to be immune suppressing. The advantage from estrogen increases with increasing level of bioavailable hormone. Although previous studies have also detected an association between female sex and survival after traumatic insults compared with male sex, this association has been proven to be stronger in premenopausal women regardless of injury mechanism. Females with firearms-related injuries have also shown to have a lower complication rate compared with males, which could be due to the lower risk of drug or alcohol use. However, the mechanism for this difference is not fully understood and warrants further investigation.

**Table 2** Comorbidities among males and females with firearms-related wounds

<table>
<thead>
<tr>
<th>Comorbidities</th>
<th>Before matching</th>
<th>After matching</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male (N=173 317)</td>
<td>Female (N=23 379)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypertension, n (%)</td>
<td>14 337 (8.3)</td>
<td>2473 (10.6)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>History of angina, n (%)</td>
<td>33 (0.0)</td>
<td>4 (0.0)</td>
<td>1.00</td>
</tr>
<tr>
<td>History of myocardial infarction, n (%)</td>
<td>365 (0.2)</td>
<td>42 (0.2)</td>
<td>0.368</td>
</tr>
<tr>
<td>Congestive heart failure, n (%)</td>
<td>719 (0.4)</td>
<td>116 (0.5)</td>
<td>0.082</td>
</tr>
<tr>
<td>History of peripheral vascular disease, n (%)</td>
<td>187 (0.1)</td>
<td>17 (0.1)</td>
<td>0.144</td>
</tr>
<tr>
<td>Cerebrovascular disease, n (%)</td>
<td>471 (0.3)</td>
<td>92 (0.4)</td>
<td>0.001</td>
</tr>
<tr>
<td>Diabetes mellitus, n (%)</td>
<td>5756 (3.3)</td>
<td>966 (4.1)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Chronic renal failure, n (%)</td>
<td>335 (0.2)</td>
<td>20 (0.1)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Dementia, n (%)</td>
<td>280 (0.2)</td>
<td>52 (0.2)</td>
<td>0.041</td>
</tr>
<tr>
<td>Chronic obstructive pulmonary disease, n (%)</td>
<td>474 (2.4)</td>
<td>781 (3.3)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Bleeding disorder, n (%)</td>
<td>1447 (0.8)</td>
<td>211 (0.9)</td>
<td>0.306</td>
</tr>
<tr>
<td>Current smoker, n (%)</td>
<td>48 995 (28.3)</td>
<td>5740 (24.6)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Currently receiving chemotherapy for cancer, n (%)</td>
<td>92 (0.1)</td>
<td>21 (0.1)</td>
<td>0.040</td>
</tr>
<tr>
<td>Disseminated cancer, n (%)</td>
<td>298 (0.2)</td>
<td>40 (0.2)</td>
<td>1.000</td>
</tr>
<tr>
<td>Cirrhosis, n (%)</td>
<td>417 (0.2)</td>
<td>41 (0.2)</td>
<td>0.061</td>
</tr>
<tr>
<td>Advanced directive limiting care, n (%)</td>
<td>607 (0.4)</td>
<td>106 (0.5)</td>
<td>0.016</td>
</tr>
</tbody>
</table>

**Table 3** Patient outcomes among men and women with firearms-related wounds

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Before matching</th>
<th>After matching</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male (N=173 317)</td>
<td>Female (N=23 379)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hospital length of stay, median (IQR)</td>
<td>4.0 (2.0–9.0)</td>
<td>4.0 (2.0–9.0)</td>
<td>0.109</td>
</tr>
<tr>
<td>Missing, n (%)</td>
<td>1970 (1.1)</td>
<td>257 (1.1)</td>
<td></td>
</tr>
<tr>
<td>Required ICU care, n (%)</td>
<td>73 262 (42.3)</td>
<td>10 173 (43.5)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>ICU length of stay, median (IQR)</td>
<td>3.0 (2.0–6.0)</td>
<td>3.0 (2.0–6.0)</td>
<td>0.879</td>
</tr>
<tr>
<td>Required a ventilator, n (%)</td>
<td>52 295 (30.2)</td>
<td>7140 (30.5)</td>
<td>0.254</td>
</tr>
<tr>
<td>Length of ventilator utilization, median (IQR)</td>
<td>2.0 (1.0–5.0)</td>
<td>2.0 (1.0–5.0)</td>
<td>0.045</td>
</tr>
<tr>
<td>In-hospital mortality, n (%)</td>
<td>32 000 (18.5)</td>
<td>4359 (18.6)</td>
<td>0.508</td>
</tr>
<tr>
<td>Unplanned admission to the ICU, n (%)</td>
<td>2292 (1.3)</td>
<td>276 (1.2)</td>
<td>0.078</td>
</tr>
<tr>
<td>Organ-space surgical site infection, n (%)</td>
<td>1527 (0.9)</td>
<td>156 (0.7)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Pulmonary embolism, n (%)</td>
<td>1099 (0.6)</td>
<td>129 (0.6)</td>
<td>0.145</td>
</tr>
<tr>
<td>DVT, n (%)</td>
<td>2719 (1.6)</td>
<td>284 (1.2)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Length of stay is measured in days.</td>
<td>721 (0.4)</td>
<td>52 (0.2)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>
be due to the injury severity-dependent increase of estrogen in the immediate post-traumatic period observed in females. However, this does not explain why the observed differences remain in patients who are ≥50 years old in the current analysis.

The limitations of our study include the inherent shortcoming of register studies and collection of granular data on care provided. Recording errors may be present due to the dependence on historical records of individual institutions, and medical records have the potential to be incomplete, invalid, or unclear. Propensity score matching in itself is limited as it only controls for recorded/observed variables. As such, any variables not recorded are not accounted for, and should be taken into consideration with analysis of results in this study. Other limitations include a lack of data on patients who died before admission to the trauma center as well as an inability to determine the cause of death in the study population. On the other hand, this large dataset also allowed for adjustments to be made for a significant amount of pre-admission comorbidities, racial and demographic differences, as well as socioeconomic status, by using patient consent for publication in the immediate post-traumatic period observed in females. 19

CONCLUSION

National data of hospitalized trauma patients demonstrate that females have lower mortality and better outcomes than males after admission for firearms-related injury. Further prospective studies are warranted to investigate the ramifications for females and trauma care underlying our findings.

Contributors CZ, SK, BS and SM conceived the study idea. CZ, MPF and SM designed, collected data, and analyzed the data. All authors contributed to critical review of the results and draft of the article. The final version submitted to TSACO was approved by all authors. SM is the author acting as guarantor.

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Patient consent for publication Not required.

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Provenance and peer review Not commissioned; internally peer reviewed.

Data availability statement Data may be obtained from a third party and are not publicly available. The data can be requested from Dr Babak Sarani by the editorial board of TSACO.

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